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User-Friendly Geological Data Tools and Guidelines Pave the Way for Geothermal Heat Supply in Lower Saxony, NW-Germany

Sandra Pester and Holger Jensen

State Authority for Mining, Energy and Geology, Stilleweg 2, 30655 Hanover, Germany

sandra.pester@lbeg.niedersachsen.de, holger.jensen@lbeg.niedersachsen.de

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ABSTRACT

The State Authority for Mining, Energy and Geology, Lower Saxony, has developed several freely available tools to help landlords decide whether shallow geothermal energy as the main source for their heating and cooling systems is an option:

A mapserver is available via internet and provides guidance regarding legal restrictions related to shallow geothermal energy, and also underground information about the expected potential of geothermal plants. The second internet tool is called "Geothermal energy – is it possible at my place?" and provides an answer to that question for any specific location in Lower Saxony. Both unique tools are also available as free applications for smartphones and tablets. The third important element is the Guideline for geothermal heat utilization in Lower Saxony. This document represents a road map that addresses different players, e. g. drilling companies and licensing authorities, operating in the shallow geothermal energy market.

1. INTRODUCTION

During the last decade, Germany has experienced a boom in the field of shallow geothermal energy. To date (end of 2013), more than 260,000 geothermal heating systems have been installed in Germany. The German government encourages the owners of buildings to choose a form of renewable energy by implementing the German Act on the Promotion of Renewable Energies in the Heat Sector (in German: Erneuerbare-Energien-Wärmegesetz, EEWärmeG). The motivation behind this is the turnaround in energy policy, called Energiewende.

Due to the laws and regulations, the percentage of heat pumps as the main heating system in new buildings has grown to about 30 % in Germany (BMU 2013). Thereof, 40 % are ground source heat pumps. Of all the ground source heat pumps in Germany, approx. 80 % are being operated with vertical heat exchangers, 15 % with horizontal heat exchangers and 5 % with open groundwater systems. Overall, the share in heat from renewable energy in Germany is about 10 %. The Federal Government wants to increase this share in the next few years. This can be done, for example, through increased use of shallow geothermal energy.

In order to help people to decide whether shallow geothermal energy is an adequate form of renewable energy for their purpose, the geological surveys of Germany provide essential data for geothermal projects. Germany is divided into 16 federal states, each of which has its own geological survey – the State Authority for Mining, Energy and Geology (LBEG) being the geological survey for Lower Saxony in northwest Germany.

This paper gives an insight into three tools provided by the LBEG that contribute to the development of shallow geothermal energy in Lower Saxony.

2. GEOLOGICAL DATA TOOLS AND GUIDELINES

The LBEG has developed several tools to help landlords decide whether shallow geothermal energy as the main source for their heating and cooling systems is an option, and what restrictions they might meet. All of the information the LBEG provides – either via internet tools like the NIBIS® mapserver and "Geothermal energy – is it possible at my place?", or as Guideline for geothermal heat utilization – are freely available and were designed as user-friendly products.

2.1 NIBIS® mapserver

The most frequently used tool is the mapserver, called NIBIS® mapserver (2014). It is available via internet and as application for smartphones. It provides map views for almost all available LBEG data on the following topics: 3D-Model Geotectonic Atlas, abandoned waste sites, area consumption and soil sealing, aerial photographs, biostratigraphy, boreholes and profiles, climate, engineering geology, erosion (Cross Compliance), geology, geomorphography, geophysics and boreholes of the deeper surface, geotopes, hydrogeology, mining, resources, cross sections, soil science, and geothermal energy.

The topic of geothermal energy comprises three different layers. Two of them provide information about the efficiency of the underground for horizontal and vertical heat exchangers. The third layer is the "Terms of use for shallow geothermal energy". Figure 1 shows a map section of that layer and indicates that shallow geothermal energy in the form of vertical heat exchangers is not permitted at every location in Lower Saxony. The terms of use are divided into permitted, conditionally permitted and prohibited areas. For example, vertical heat exchangers are not permitted near a drinking water well, in order to assure the drinking water abstraction against possible disturbance. Further from such a well but still within its catchment basin, vertical heat exchangers are only permitted under certain conditions, which are described in the Guideline for geothermal heat utilization in Lower Saxony (see chapter 2.3). There are other regions where vertical heat exchangers are only conditionally permitted – mainly due to drilling complications that might arise from geological or hydrogeological conditions like shallow-lying salt domes (up to 200 m below the surface) or regions influenced by mining. Further conditionally permitted areas include mineral spring protection zones, saltwater

intrusion zones, areas with layered groundwater structure (stockwork structure) and sinkhole hazard areas. Other regions where drillings might pose risks are not yet mapped. For example, a map characterising regions with possible swellable sulphate deposits is currently prepared and will be added to the conditionally permitted areas in the near future. All those data are also available as individual maps of the NIBIS® mapserver. The layer "Terms of use for shallow geothermal energy" is thus a summary map to allow easy access to the relevant information for the layman and to provide a simple approach for landlords to determine whether vertical heat exchangers are possible at their location. The layer is updated regularly and extended with newly obtained information about subsurface conditions.

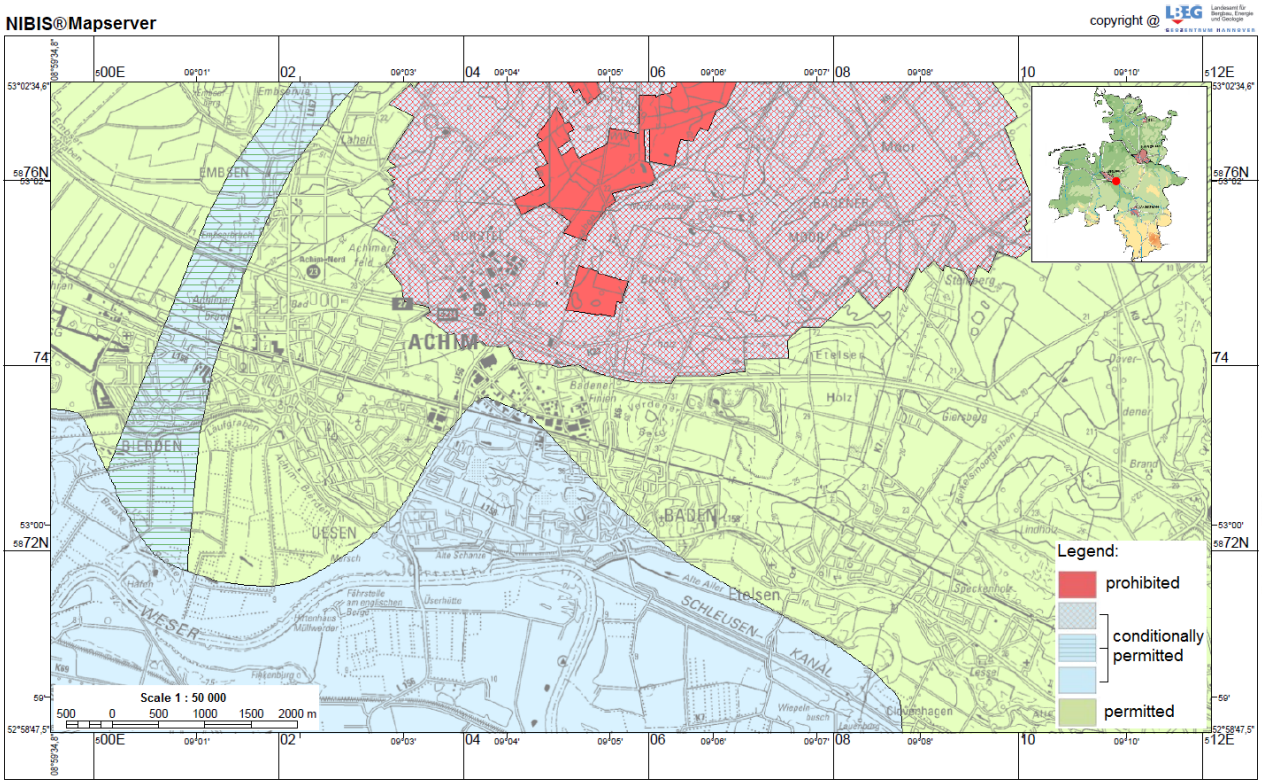

Figure 1: Map section of the layer "Terms of use for shallow geothermal energy" from the NIBIS® mapserver showing permitted, conditionally permitted and prohibited regions for vertical heat exchangers.

2.2 Geothermal Energy – is it Possible at my Place?

The second internet tool is called "Geothermal energy – is it possible at my place?" (LBEG 2010). It will give the user a rough estimation of whether shallow geothermal energy, in form of horizontal and vertical heat exchangers, is energetically as well as economically worthwhile at any location in Lower Saxony. It evaluates site-specific data based on the NIBIS® mapserver including the map "Terms of use for shallow geothermal energy". The input data required for the calculation for vertical heat exchangers consists of ground elevation, depth of groundwater table (saturated/unsaturated soil), thickness of loose rocks, and type of hard rocks. Based on a 50 m grid, the specific heat extraction for a 100 m vertical heat exchanger is calculated. For horizontal heat exchangers, the calculation is based on soil maps with attached databases. The required input data includes soil types, depth of groundwater table, compactness of soils, effective heat capacity, and moisture content (Dehner et al. 2007). With these data, a classified vector map (scale 1:25000) is produced.

As shown in figure 2, the tool requires only limited input data by the user, one of which being the specific location either via address, mouse click on a digital map, or GPS in smartphones. Furthermore, input about the specific energy requirement is needed. The results will be more accurate if the energy consumption is entered as litres of fuel oil per year or cubic metres of natural gas per year. Since this information is often either not known or unavailable, the tool provides the option to select the type of building and enter the living space in square metres (heated floor area). Depending on the selected type of building, ranging from old building without energetic upgrades to passive house (most advanced energetically optimized building), the system will calculate an estimated energy consumption.

The result will be an estimation of the feasibility of shallow geothermal energy at the chosen location. The outcome not only determines suitability from an energy efficiency point of view, but also provides relevant information for permitting requirements by the water authorities. The tool differentiates between horizontal and vertical heat exchangers, and shows the possible reasons for restrictions. Alongside this information, which can also be obtained from the NIBIS® mapserver, the tool provides an estimation of the required length of vertical heat exchangers, or area of horizontal heat exchangers, necessary to replace the current heating system. Additionally, the user will receive information about the anticipated costs of installing the subsurface geothermal system. This tool only provides a rough estimation which cannot replace the calculation of a consultant.

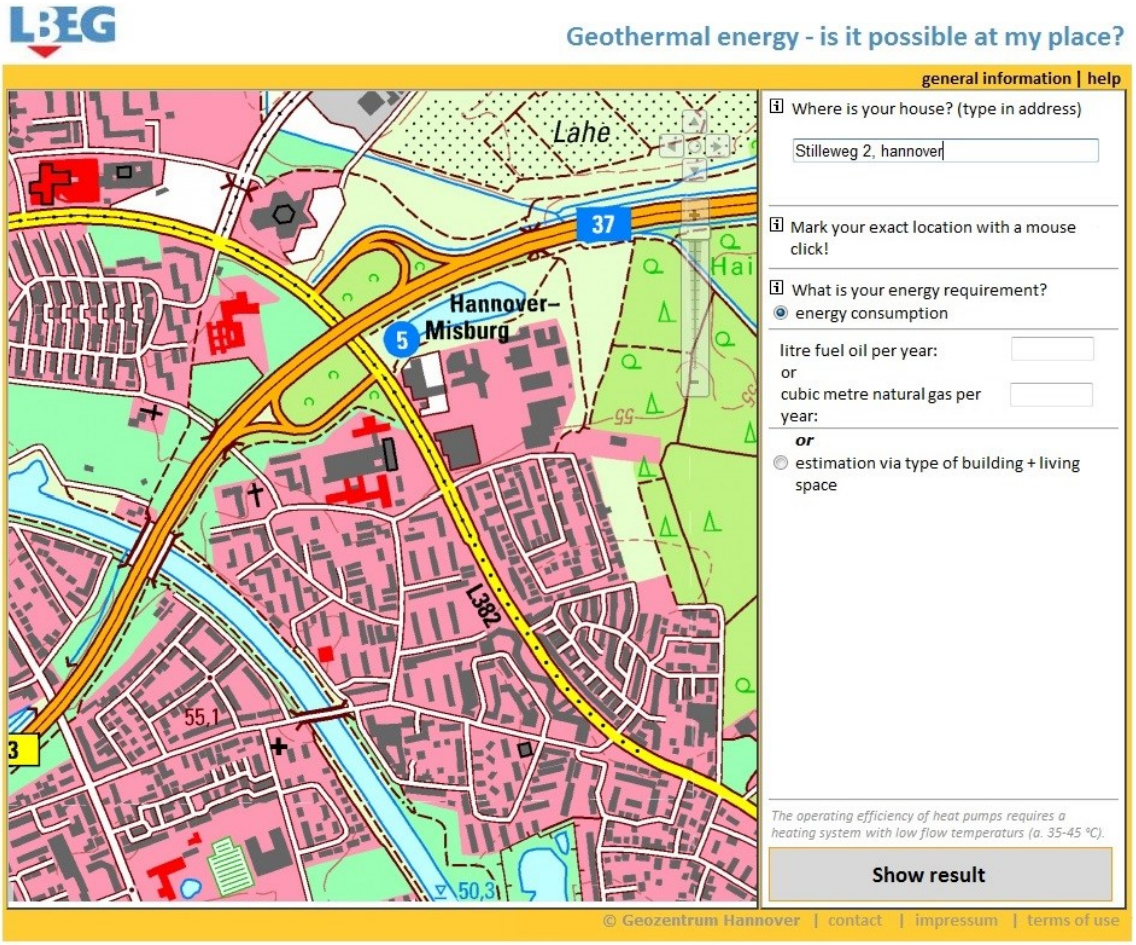

Figure 2: Screenshot of the internet application "Geothermal energy – is it possible at my place?"

2.3 Guideline for Geothermal Heat Utilization

Another important element is the Guideline for geothermal heat utilization in Lower Saxony (Ast et al. 2012). This document represents a road map that addresses different players, e. g. drilling companies and licensing authorities, operating in the shallow geothermal energy market. It describes the technical and scientific fundamentals as well as the licensing procedures of the local water authorities. Depending on the proposed location of a new geothermal system, the site can be located in a permitted, conditionally permitted or prohibited region for the use of shallow geothermal energy (see chapter 2.1). The resulting recommendations for each of these regions are described in the guideline.

Figure 3 shows an example of recommendations given in drinking water protection zones: the drinking water well is producing from an upper aquifer which is separated from a lower aquifer by an aquiclude. If the planned vertical heat exchanger were to be located near the drinking water well but outside the prohibited zone, it would not be permitted to be drilled through the aquiclude. This conservative approach assumes, that in the worst case, a well penetrating an aquiclude may damage the separation of two groundwater bodies, and makes sure that the drinking water cannot mix with deeper groundwater that may not have drinking water quality (e. g. due to higher salt content). Furthermore, the heat exchanger has to be operated with heat transfer fluid not hazardous to water like water itself or carbon dioxide. To control this, an independent expert should supervise the construction of the heat exchanger. A vertical heat exchanger at a greater distance from the drinking water well but still within the drinking water protection zone can be operated with the usual heat transfer fluid (e. g. ethylene glycol) and may also be drilled through the aquiclude but the supervision by an expert is also advised to ensure that separation of the aquifers will be re-established.

For other areas that are classified as conditionally permitted due to special geological or hydrogeological conditions, similar adapted recommendations are provided. Advice is given regarding drilling techniques, distances to other plants or plots, as well as recommended maximum drilling depth. Next to those location-dependent recommendations, general directions for the installation of a geothermal plant are given in this guideline. The guideline also provides forms for the documentation that has to be submitted to the water authorities within six months upon completion of the work.

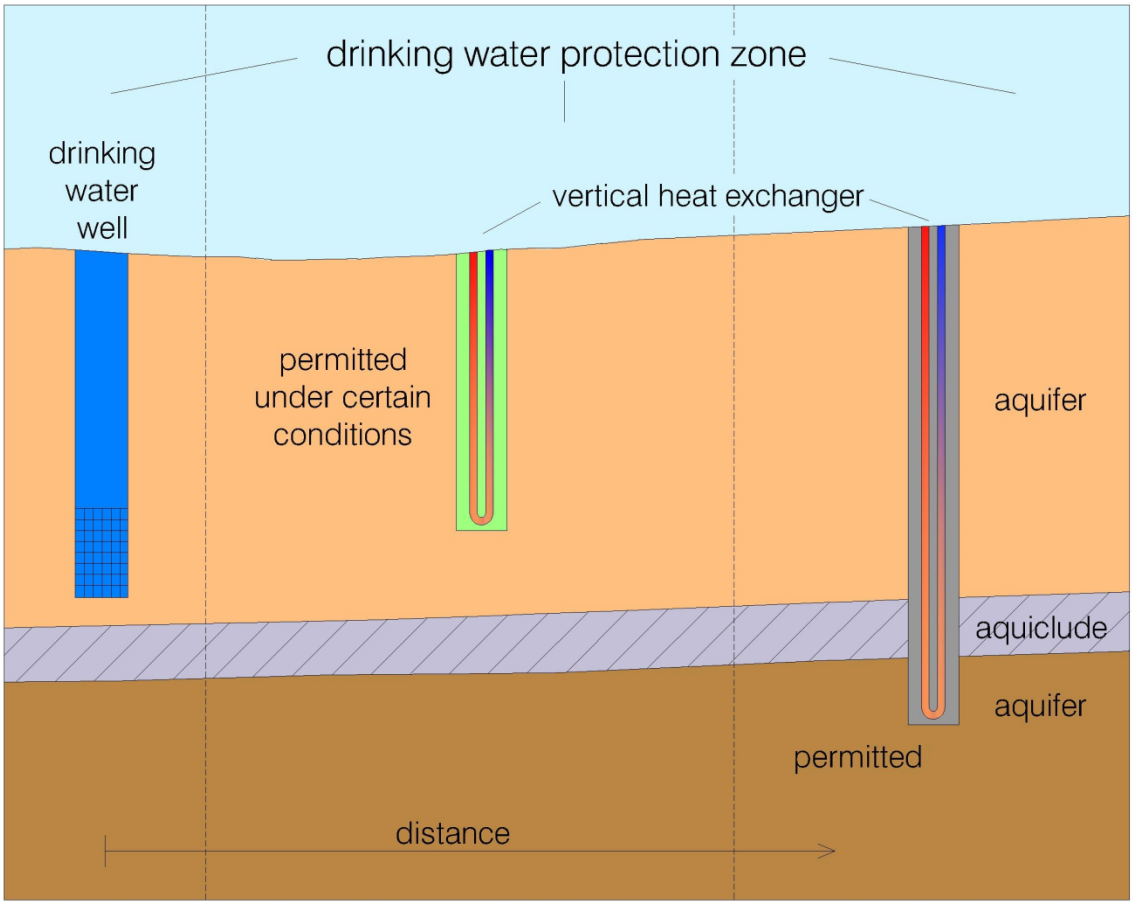

Figure 3: Example of recommendations given in drinking water protection zones in the Guideline for geothermal heat utilization in Lower Saxony.

4. CONCLUSIONS

An increasing number of landlords in Lower Saxony are choosing geothermal energy as the main source for their heating and cooling systems, as shown by the increasing number of drilling notifications. This trend demonstrates that the installation of geothermal systems is a successful approach in many cases and an effective instrument in contributing towards achieving the goals of the Energiewende.

The two online tools and the guideline provided by the LBEG, help to both support and regulate the developments in the field of shallow geothermal energy. The online tools can help to minimize the exploitation risk and to estimate the efficiency of a planned plant. They are user-friendly and support landlords that intend to decide whether shallow geothermal energy is a suitable option at any specific site in Lower Saxony, and which system may be used preferentially. Additionally, the tools provide information about expected drilling complications due to specific hydrogeological and geological conditions. The guideline defines consistent technical standards, gives advice on how to proceed in different hydrogeological and geological conditions, and helps through the licensing procedure. The high online access rate of approx. 3000 accesses per year shows that those tools are widely accepted and are being used frequently.

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